National Agricultural Research, Extension, Education, and Economics (NAREEE) Advisory Board

MINUTES OF THE CITRUS DISEASE SUBCOMMITTEE MEETING

January 25-26, 2018
U.S. Horticultural Research Laboratory (ARS),
2001 S. Rock Road, Fort Pierce, FL, 34945

CONTENTS

Respectfully submitted,

_____	_____	_____
Tom Jerkins	Dr Etienne Rabe	Michele Esch
Chair	Vice Chair	Executive Director

APPROVAL BY ADVISORY BOARD: _____
Date

_____	_____
Initials	Initials
Chair	Executive Director

EXECUTIVE SUMMARY

The Citrus Disease Subcommittee (CDS), a statutory subcommittee of the National Agricultural Research, Extension, Education, and Economics (NAREEE) Advisory Board, met in public session on January 25-26, 2018, in Fort Pierce, Florida. The meeting's main goals were to hear presentations from new Project Directors about their research projects funded through the Citrus Disease Research and Extension Program (CDRE), part of the National Institute of Food and Agriculture (NIFA) Specialty Crop Research Initiative (SCRI), and to discuss the CDRE annual budget, agenda, and funding priorities.

SUMMARY OF PRESENTATIONS

CDS Chair Tom Jerkins gaveled the meeting to order. Michele Esch, the Executive Director, NAREEE Advisory Board, and Designated Federal Officer, CDS, provided an overview of the meeting agenda and the mission of CDS, which was established in the 2014 Farm Bill. Chair Jerkins suggested that the Subcommittee could conclude its business in a single day by extending the January 25 meeting, with a field tour the following day. He remarked that because of the widespread Huanglongbing (HLB) disease, Florida's citrus industry is in much worse condition than when the Subcommittee first met, and growers in Texas and California are facing threats; however, he remains optimistic about meeting the HLB challenge. The CDS members and all who were present at the meeting introduced themselves. NIFA Institute of Food Production and Sustainability Deputy Director Dr. Parag Chitnis was unable to attend the meeting, so the agenda moved directly to Project Directors' presentations.

Five SCRI/CDRE Project Directors gave presentations on the goals of their research projects and accomplishments to date. The presentations were:

- Bryony Bonning, University of Florida, presented on *Bt Toxin-based Strategies for Management of* Diaphorina citri *and Citrus Greening.*
- Feng Luo, Clemson University, presented on *Selection, Molecular and Genetic Analysis of HLB Tolerant/Resistant Variant Citrus Plants*.
- Caroline Roper, the Regents of the University of California, presented on *Deployment Of A Spectrum Of Bactericides To Cure And Prophylactically Treat Citrus Huanglongbing*.
- YongPing Duan, USDA-ARS, presented on Identification, *Assessment and Delivery of Antimicrobial Compounds for the Management of Citrus HLB*.
- Jude Grosser, University of Florida, presented on *An Integrated Approach to the Accelerated Development of Rootstocks that Impart HLB Tolerance to Trees Grafted with Commercial Scions*.

In addition to the Project Directors' presentations, CDS members were invited to a Poster Session that was set up in the meeting room to learn more about the projects.

Dr. Tom Bewick, National Program Leader, NIFA, gave an overview of CDRE program activities and the current status of awards. He began by noting that the new Program Specialist is Megan O'Reilly; the Relevance Review Panel Manager is Harold Browning; and the Scientific

Merit Review Panel Manager is Neil Gudmestad, who will be replaced next year by Jeff Chang of Oregon State University.

Dr. Bewick then reviewed the submissions data. For the first submission date, there were 38 pre-applications received and assigned to four panels, with each panel having nine industry reviewers. The panels invited 26 full applications, and five awards were announced. For the second submission date, which has a deadline of February 15, CDRE received 10 pre-applications, including several from non-citrus teams. However, none of the submissions were in the final stages. Three proposals were invited to submit full applications. Approximately $2.4 million is available. Dr. Bewick explained that the Relevance Review Panels decided which pre-applications to invite, ranking them based on the importance of the research to industry. The Scientific Merit Review Panel rated projects by merit, and then developed its funding recommendations by combining the relevance and merit rankings. Dr. Browning was present at the meeting when the Scientific Merit Panel developed funding recommendations, which were made giving significant weight to a project's relevance.

CDS members received 250-word summaries of the 2017 awards and Dr. Bewick listed the titles on a slide:

- *Biopesticidal Dsrna Therapy for Psyllid Mortality and Abatement of Vector-Mediated CLas Transmission*
- *Citrus Under Protective Screen (CUPS) For HLB Management*
- *Transgenic Success-Guided Reproduction of Huanglongbing Disease Resistance/Tolerance in Citrus by Gene Editing*
- *Development of Non-Transgenic HLB Resistant Citrus Varieties Using CRISPR-Cas9*
- *Accelerating Implementation of HLB Tolerant Hybrids as New Commercial Cultivars for Fresh and Processed Citrus*

During the question and answer session, Dr. Bewick affirmed that the number of grant applicants was declining, from 69 in the first year to 38 in the current year. But projects are in the pipeline. It was clarified that if there were no new Farm Bill, the CDS would continue to meet and consult with NIFA, even if no new funding was available for the panel to consider. A CDS member noted that researchers would benefit from knowing what was previously funded. It was agreed that Megan O'Reilly will work with the NIFA information technology staff to update the webpage housing all NIFA projects and reports, and Michele Esch will develop a link that CDS members and researchers can go to directly.

A CDS member asked how the Subcommittee's priority recommendations fit into the CDRE award determination. Dr. Bewick explained that the 2017 CDS-ranked priorities were used to give greater weight to projects with high relevancy and scientific merit scores; for example, if equal in relevance and merit, a project that matched the CDS's top-ranked priority would receive greater weight than a project matching the CDS's fourth-ranked priority. Members discussed the issue of supplemental funding for existing projects, and a CDS member requested that NIFA inform them about the process for seeking supplemental funds once it is clarified. A member asked if the CDS could recommend that no more new projects receive funding and that all remaining funds be set aside for supplemental awards. Dr. Bewick responded that NIFA has the authority and if CDS made such a recommendation the leadership would have to consider it.

Dr. Gail Wisler, Retired, National Program Leader for HLB/Asian citrus psyllid (ACP) Research, USDA-Agricultural Research Service (ARS), gave a presentation on *ARS Research Update on Citrus Diseases*. She began by describing differences among the USDA partners working on HLB solutions: ARS, NIFA, and the Animal and Plant Health Inspection Service (APHIS). USDA's HLB National Plan targets all three components of the problem: the ACP vector, the associated pathogens, and the citrus hosts. When HLB hit Florida in 2005-2006, ARS responded with an "all hands on deck" that refocused research at ARS locations around the country on various aspects of the disease and solutions. Dr. Wisler presented a map showing the increase of ACP over time. She presented information about research conducted at the ARS Parlier, California, station, that has identified and targeted *Liberibacter asiaticus* virulence genes, with preliminary tests showing enhanced growth of citrus trees treated with selected compounds. She reviewed other promising research. Dr. Wisler described the ARS-wide 2017 Grand Challenge aiming to "Transform agriculture to deliver a 20 percent increase in quality production at 20 percent lower environmental impact by 2025." The ARS administration recognized HLB as one of agriculture's greatest challenges. In 2017, $18.7 million went to projects coded for citrus, and $2.3 million for citrus greening.

During the question and answer session, Dr. Wisler was asked about quarantine zones she depicted, and she replied that Georgia should be able to move material within weeks. Samples have been drawn and analyzed.

Dr. Angela McMellen-Brannigan, USDA-APHIS, gave an update via teleconference on the *Huanglongbing Multi-agency Coordination Group (HLB MAC)*, whose goal is to get tools to growers within 1-3 years, starting with two-year funding of $20 million in Fiscal Year (FY) 2014 and an additional $5.5 million slated for FY16-17 and FY17-18. She noted several vector control projects being funded using $2 million of $11 million available. Two projects are directed at the field management of HLB using approximately $500,000 out of $8 million, several projects are funded at approximately $2 million, and an additional $1.5 million is being spent on other projects. Because not all of the $11 million has been spent, money will be left at the end of the fiscal year, and the HLB-MAC wants to evaluate if biocontrol and early detection are worthwhile as priority research areas. At the request of the CRDF, the National Academy of Sciences (NAS) is conducting a comprehensive review of HLB efforts since 2005, following up on a 2009-2010 review that NAS published, with a final report due in March.

KEY ISSUES AND DISCUSSIONS

Recommendations and Priorities for CDRE FY2018

The afternoon discussion focused on the CDRE 2018 agenda and priorities. DFO Michele Esch opened the discussion by presenting an overview of the CDS charge and reviewing the goals for the afternoon. She presented a list of the 2014-2017 CDS priorities. Ms. Esch posted the 2017 rank-ordered priorities for discussion by the CDS. They were:

1. Therapies to prevent or suppress *Candidatus Liberibacter asiaticus* (CLas) bacteria within trees.

2. Development of tolerance or resistance in commercial citrus in all production areas with a focus on delivery of new cultivars (or rootstocks and scions) using all available strategies.
3. Systems for delivery of therapies into the phloem of citrus trees.
4. Culturing or cultivating the CLas bacterium.
5. Early detection of the bacterium in host and vector.
6. Development of pre- and post-harvest tools to maximize citrus fruit quality for use in fresh fruit or processed products.

Members discussed individual priorities, including whether any should be removed. Members spoke at length about the critical culturing issues and current research that has been funded to address the challenge. Based on the discussion, Chair Jerkins concluded, without dissent, that culturing remains elusive and should remain on the priority list. A member added that a process is needed to be sure supplemental funding for culturing can be obtained if necessary without having to resubmit a completely redone project proposal. Together with Dr. Bewick, the CDS reviewed the funding amounts, which equal $24.4 million, and Chair Jerkins requested that for clarity an Excel spreadsheet be created so the CDS can see the numbers. It was agreed NIFA can create such a spreadsheet for the members.

After obtaining agreement that none of the six 2017 priorities should be removed, Chair Jerkins asked if any should be added. CDS member Joe Davis, Jr., raised the issue of root health as critically important. Members agreed to modify 2017 priority number 3, adding the words, *including the root system*. After a brief discussion about whether the issue was root health or the whole tree, the CDS also approved a new priority that read: *Improve productivity of infected trees, including root health*.

Project Director Dr. Duan offered his view that 2017 priority number 2 required a reference to the variety of pathogenic strains because there are clear differences in strains from Florida and California, so strains from all major areas should be used. Members agreed to modify priority 2, adding the words: *with consideration of pathogen genetic diversity*.

Chair Jerkins called for a motion to accept all seven of the priorities now listed for 2018 and the list was unanimously adopted. He then opened the floor to discussion of how the priorities should be ranked in importance. Following discussion, the CDS produced the following consensus on the 2018 rank-ordered priorities list:

1. Therapies to prevent or suppress *Candidatus Liberibacter asiaticus* (CLas) bacteria within trees.
2. Development of tolerance or resistance in commercial citrus in all production areas with a focus on delivery of new cultivars (or rootstocks and scions) using all available strategies, with consideration of pathogen genetic diversity.
3. Improve productivity of infected trees, including root health.
4. Systems for delivery of therapies into the phloem of citrus trees, including the root system.
5. Culturing or cultivating the CLas bacterium.
6. Early detection of the bacterium in host and vector.
7. Development of pre- and post-harvest tools to maximize citrus fruit quality for use in fresh fruit or processed products.

A CDS member made a motion to add language to the FY2018 letter to the Secretary that would convey the idea of reserving a portion of any remaining funding to supplement existing projects. Discussion resulted in agreement to convey to the NIFA director that "*the intent is for an amount of funding, not to exceed 25 percent, to be awarded to advance existing projects if justified by merit in light of these seven priorities*."

Ms. Esch sought CDS comments on grants awarded as a way to test how the awards process is working. Members raised concerns about the fact that the five awards made in 2017 included a project on *Citrus Under Protective Screen (CUPS) for HLB Management*, although CUPS is not a CDS priority. Chair Jerkins suggested that, since members were not asking for any action to be taken on the CUPS project, there should be no comment, and no members disagreed.

BOARD BUSINESS

Chair Jerkins turned to the topic of changing the CDS membership. Ms. Esch pointed out that all but three members had reached their maximum six-year terms and would rotate off, although a request can be made to extend the terms of three members for an additional year. Members agreed that extensions should be requested because it would be too disruptive for CDS to lose all except three members at once. Ms. Esch said NAREEE would issue a call to replace three members for appointments starting October 1, 2018. Citrus producers are required, with these numbers from each state: Florida (5), California (3), and Texas (1). Chair Jerkins requested that members who have reached their six-year limit send Ms. Esch an email indicating their willingness to serve an additional year. She requested that CDS members suggest candidates to serve as new members.

Members discussed possible locations for the 2019 CDS meeting. Arizona and Fresno, California, were named as potential locations.

On Friday, January 26, 2018, the CDS and several project researchers met at the ARS Horticultural Research Laboratory at 8:30 for a tour of the facility and fields.

RESOLUTIONS AND RECOMMENDATIONS

- A CDS member suggested that it would be helpful to see the 38 project proposals for last year categorized according to which of the 2017 priorities they matched.
- CDS members expressed interest in the possibility of setting aside a portion of remaining CDRE funds for use as supplemental dollars for existing research projects, such as culturing research; for clarity on the funding issue, they requested that NIFA create an Excel spreadsheet so the CDS can see the amount of CDRE funds that have been spent and the amount remaining.
- The CDS, after reviewing the 2017 priorities, modifying two, and adding a new one, unanimously adopted the new list of priorities.
- After discussion, the CDS conducted a voting procedure to rank order the 2018 priorities and adopted a final rank order that will be influential in funding recommendations, with higher priority goals receiving greater weight.

- The CDS supported NAREEE requesting an additional one-year extension for members whose term has reached the maximum six years.

ACTION ITEMS

- Megan O'Reilly will work with the NIFA information technology staff to update the webpage housing all NIFA projects and reports, and Michele Esch will develop a link that CDS members and researchers can go to directly.
- NIFA will inform the CDS members about the process for making supplemental funding awards to existing projects.
- Tom Bewick will classify the 38 research project proposals received last year according to which of the six 2017 CDS priorities the proposals matched and make the information available to CDS members.
- NIFA will create an Excel spreadsheet so the CDS can see the amount of CDRE funds that have been spent and the amount remaining.
- CDS members who have reached the maximum of their six-year terms will send Michele Esch an email indicating whether they would be available to extend another year.
- Michele Esch will request a one-year extension for three CDS members who have reached their six-year term maximum but are willing to extend their service another year.
- NAREEE will issue a call for three new CDS members for appointments starting October 1, 2018.
- CDS members will suggest candidates to serve as new CDS members.

THURSDAY, JANUARY 25, 2018

PART I: Welcome and Introductions

Tom Jerkins (Chair, Citrus Disease Subcommittee of the NAREEE Advisory Board, hereafter "CDS") called the meeting to order at 8:15 a.m.

INTRODUCTION OF MEMBERS AND OTHER ATTENDEES

Michele Esch (Executive Director, NAREEE Advisory Board, and Designated Federal Officer, CDS) welcomed everyone to the CDS's fifth meeting. She noted that it was open to the public as a Federal Advisory Committtee Act meeting and then reviewed the agenda as well as the background of the CDS, which was established under the 2014 Farm Bill to consult with the National Institute of Food and Agriculture (NIFA) on an annual basis and to provide recommendations for the Institute's agenda, budget, and priorities. Ms. Esch noted that on January 24 USDA Secretary Sonny Perdue released broad principles for the next Farm Bill, although recognizing that the legislation will clearly be Congress's to write. Secretary Perdue has emphasized that USDA will be data-driven and science-based in its decisions.

The CDS members and all who were present at the meeting introduced themselves.
Note: A list of attending CDS members and other participants for each session of the meeting is provided in Appendix A of this report.

SAFETY AND HOSPITALITY

Shirley Morgan-Jordan (NAREEE Program Support Coordinator) provided safety and hospitality information to the subcommittee.

WELCOMING COMMENTS

CDS Chair Tom Jerkins (Premier Citrus) welcomed everyone to the meeting. Noting that the CDS had become more efficient in conducting its business, he suggested that the Subcommittee could conclude its business in a single day by extending the January 25 meeting, with a field tour the following day. He remarked that because of the widespread Huanglongbing (HLB) disease, Florida's citrus industry is in much worse condition than when the CDS first met, and growers in Texas and California are facing threats; however, he remains optimistic about meeting the HLB challenge.

OPENING REMARKS

NIFA Institute of Food Production and Sustainability Deputy Director Dr. Parag Chitnis was unable to attend the meeting, so the meeting moved directly to Project Directors' presentations.

PART II: SCRI/CDRE Project Director Presentations

PROJECT DIRECTOR PRESENTATIONS

- **Dr. Bryony Bonning (University of Florida)**, *Bt Toxin-based Strategies for Management of* Diaphorina citri *and Citrus Greening*

Dr. Bonning stated that with the Asian citrus psyllid (ACP) causing citrus greening, or HLB, the project is focused on developing an environmentally benign approach using a *Bacillus thuringiensis* (Bt) based toxin that would help citrus growers manage ACP within an integrated pest management (IPM) framework. Bt is a soil bacterium that produces spores and insecticidal crystal (Cry) toxins. Bt is widely used for organic agriculture sprays to control mosquitoes and other disease vectors and on transgenic crops, including corn and cotton, for insect pest control. Bt toxins are safe for humans and non-target species. Because sap-sucking insects are not susceptible to Bt toxins, a gut binding peptide (GBP) is added to make the toxins effective against insects such as ACP.

Following her project concepts overview, Dr. Bonning described the project's four objectives: 1) to identify additional Bt toxins that are active against ACP and to optimize their efficacy; 2) to develop delivery approaches suitable for use in Florida, Texas, and California; 3) to evaluate the economic impact of the Bt toxin-based delivery strategies; and 4) to deliver the information to stakeholders. She reviewed possible delivery methods, including introducing the Bt into the Citrus tristeza virus as a vector; using phloem-inhabiting bacteria; using transgenic citrus; and using Indian curry as a transgenic trap plant. During the project's first six months, researchers have made progress in identifying Bt toxins. They have identified Bt toxins Cry1Ab and Cry1Ba as affecting ACP, and they have isolated and characterized a gut-binding peptide GBP15, resulting in Cry1Ba engineered with GBP15 at three sites. They have identified an additional toxin with greater ACP toxicity and are screening additional strains. Researchers have also made progress in developing the delivery systems.

Regarding economic evaluation, the project goal is to develop a bioeconomic evaluation protocol that will link changes in the rate of HLB spread to management alternatives and to the costs and benefits of those alternatives. The researchers will complete a farm level analysis of how each effective Bt-toxin and delivery method affects grower costs to produce citrus. They also will complete an area-wide analysis of how each effective Bt-toxin and delivery method affects the rate of spread of HLB and will evaluate regional methods to manage the disease. And they will complete a market analysis of how changes in citrus production and costs affect final market prices and quantities. Using data from these analyses, they will estimate net benefits to consumers and growers. Toward their goal of delivering information to stakeholders, the researchers have developed a survey using literature reviews and industry input, and in the first year collected data from 112 respondents. Data show growers do not oppose Bt, and have no preference for a particular delivery method. Growers' main concern is the public response to use of Bt toxins. Among other progress, the project has established outreach through the Science for Citrus Health website. Biannual reports are due in November and May. Advisory group meetings have been held with in-person meetings planned for each of the three states.

Q&A

During question and answer discussion, a CDS member asked about Indian curry's susceptibility to cold and the answer was unknown, but it was agreed the plant would need to be hardy. It was also noted that Bt toxins are designed to kill the ACP but will not wipe out biological control agents that might also be part of a management process. HLB is a complex disease and Bt toxins are expected to be one of a diverse set of tools. A member recommended that the economic analysis include juice quality, which accounts for 15-20 percent of the loss from HLB and should be considered in the model. Groundwork has been done for Cry51 used to target another sap-sucking insect; an issue will be whether a microbial or transgenic approach is used. Bt is used in the organics industry for vegetable, and in cotton and corn for livestock food, not human consumption. There are no transgenic foods with Bt toxin, and for organic foods the whole bacterium is used, not just the toxin. Regarding the regulatory pathway for approval of the Bt-based tools, it will depend on the toxin used. It was agreed the regulatory pathway will not be easy, but companies are pushing ahead on regulatory hurdles. Although Dr. Bonning suggested that it was too early for the project's advisory group to have discussed regulatory issues, a CDS member responded that it was not too early and it was agreed the June advisory group agenda would include regulatory issues. CDS members expressed interest in the advisory board's use of milestones and corrections in reporting, and it was noted that this should be part of all advisory groups for oversight purposes. By keeping track of whether progress is falling off, funds can be redirected, and re-budgeting can be done easily if it involves less than a 10 percent shift in the project budget. Not all scientists embrace milestones. USDA only requires annual meetings; requiring more would necessitate *Federal Register* notices and would raise Paperwork Reduction Act issues. A CDS member emphasized the need for constantly affirming that a project's objective is right, depending on what research shows. As a final issue, a member asked about the binding affinity of the Bt toxins, which was unknown, and emphasized the need for a tight binding to avoid the ACP developing resistance.

- **Dr. Feng Luo (Clemson University)**, *Selection, Molecular and Genetic Analysis of HLB Tolerant/Resistant Variant Citrus Plants*

Dr. Luo said that his project participants are a multi-disciplinary group, including specialists in bioinformatics and genomics. Dr. Luo noted that after more than 10 years of HLB, and with tens of millions of infected trees in groves across Florida, researchers have observed field resistance or tolerance to HLB in some citrus plants in commercial groves and breeding orchards. These observations provide evidence of variations in HLB tolerance and resistance in the citrus gene pool. The project hypothesizes that screening natural mutant citrus plants or bud sports of commercially grown cultivars with a greater tolerance or resistance would allow researchers to take advantage of existing genetic variations and deliver HLB tolerant or resistant cultivars with desirable fruit traits. Besides selecting varieties with tolerance or resistance and identifying the genes that impart those qualities, the project's objectives include 1) developing new resistant varieties through gene editing using CRISPR-Cas9 on the identified target genes, 2) evaluating new varieties in field plantings in California, Florida, and Texas, and 3) disseminating the results to growers through active outreach and extension.

Reviewing the project's progress during the first year, Dr. Luo said that the researchers have evaluated 22 lines of volunteer seedlings (Ruby Red grapefruit) selected from Scott groves, in Fort Pierce, Florida, and four Duncan seedling selections from the U.S. Horticultural Research

Laboratory (USHRL) greenhouse using graft inoculations. The project also selected a couple of pomelo bud sports and three tolerant sweet orange clones from irradiation treatments. Researchers employed RNA-sequencing methods to study the molecular mechanism of HLB tolerance using the tolerant sweet orange lines from the University of Florida Citrus Research and Education Center breeding program. They resequenced two HLB-tolerant pomelo varieties to understand the genetic and epigenetic mechanisms of HLB tolerance. Based on previous genetic analysis, the researchers have started to edit the DMR6 gene in grapefruit and a related inter-specific hybrid cultivar Carrizo. They have co-cultivated more than 5,500 stem segment explants of Duncan grapefruit and Carrizo and regenerated more than 30 shoots that tested positive for Green Fluorescent Protein, an important visual marker in transgenic citrus research.

In addition, the project has formed a Stakeholder Advisory Committee that includes both citrus producers and cooperative extension personnel from Florida, Texas, and California, and has continually publicized its efforts through social media and meetings. The 2018 advisory group meeting has already been planned and field plot approval is underway for a California Evaluation Field Plot focusing on testing and releasing germplasm. Outreach included establishing a Material Transfer Research Agreement between USDA/ARS and Florida growers for bud sport and volunteer seedling selection and evaluation.

Q&A

During question and answer discussion, Dr. Luo explained that the project selected the most commercial variety of grapefruit for evaluation, and in the groves selected the trees that showed comparatively better performance in the field. Although pomelos are not commercial, they were selected because they were not sick, raising questions as to why this was the case. The goal is to understand the underlying causes of variations observed in plant performance. There was no comparison of 100 percent HLB-free grapefruit-scapes and infection-free Valencia-scape budwoods. The critical issue in evaluating resistance is the strain that is used. One CDS member asked if the researchers had considered the possibility that genetic variation in ACP rather than in the plants was the reason for low infection rates in some samples. Dr. Luo responded that psyllid populations could be mixed but researchers did not sequence them and to do so would have to conduct single-cell sampling. Responding to another question about whether changes in bud sports were more epigenetic or simply the result of irradiation, Dr. Luo said that it was too early to get into that level of analysis, but with pomelo the researchers have seen phenotypes correlated with resistance and are hoping to find epigenetic or real mutations in other fruit with mutations. Transgenic rootstocks are being used as a research tool, not for placement in the fields, and the intention is not to produce a transgenic plant in the end. The scions will not be transgenic. Regarding the selection of advisory group members, especially those representing California, a CDS member emphasized the need to obtain diverse perspectives and avoid having the same stakeholders serving on several committees.

- **Dr. Caroline Roper (the Regents of the University of California)**, *Deployment Of A Spectrum Of Bactericides To Cure And Prophylactically Treat Citrus Huanglongbing*

Dr. Roper began with an overview of the project's 11 Principal Investigators (PI), most from University of California Riverside, and the advisory group, whose five members rotate on and off to keep the membership dynamic. Dr. Roper reviewed the project's four broad objectives: 1) to optimize formulations of chemical bactericides to facilitate phloem mobility; 2) to harness the

power of bactericides produced by citrus-inhabiting microbes; 3) to test bactericides for phloem mobility and as HLB therapies; and 4) to integrate the research and extension activities. Dr. Roper noted that there is scant information about phloem access, so researchers studied phloem transit pathways, which are difficult to follow in woody plants. Research focused on defining the phloem functional and structural connections and source/sink pathways. Researchers asked whether HLB infections change pathways. They used dye-tracking and radiolabeled C-14 carbon that can be tracked after the plants assimilate the material through the leaves and the carbon travels to the roots. Cucumber was used for analysis. Researchers are analyzing microbial communities in "survivor trees" found in groves, extracting microbial DNA from trees rated as healthier. To profile the microbiome of HLB-infected Florida citrus, 10 trees were selected with a range of HLB symptoms and samples were taken of their leaves, budwood, and roots, followed by DNA extraction from the tissues. Researchers then sequenced the trees' bacterial and fungal communities. Molecular networking analysis was conducted to correlate microbial presence with metabolite presence, to gather information on which microbes produce helpful metabolites, and to differentiate sick from survivor tree microbes and metabolites.

Researchers are conducting molecular mapping, or 3D cartography, starting with inoculated greenhouse trees with psyllids to determine how the plant metabolome changes over time. They will also conduct mapping in the field, with the ability to map the whole tree or part, and could map all of Florida. The project is using targeted metabolomics for natural bactericide product discovery. Researchers have outlined experiments that provide information about which microorganisms are associated with citrus and that also include metabolomic experiments that will allow them to begin assigning functions. Researchers are specifically interested in assigning competitive functions to a specific microbe or microbes within the larger community of the plant and microbiome system. Assigning of microbiome functions will significantly advance science in the phytobiome field and for the HLB research community. The project's goal will be to harness the information about functions to exploit the microbe-produced metabolites as potential anti-*Candidatus Liberibacter asiaticus* (CLas) applications. The project is studying nanoparticle technologies, nano silver and nano sulfur, because nano silver is found in many products and sulfur is sprayed on many crops. After tests showed that the nano materials inhibited surrogates in plate tests, researchers have begun testing the materials on greenhouse trees. The project's extension and outreach involves two people who are leading efforts to obtain grove samples. The project members attend stakeholder events, have developed brochures to discourage hobbyists from budwood trading, and engage in various levels of educational outreach.

Q&A

During the question and answer session, a CDS member asked why the project was seeking to identify natural products rather than tapping into the large library of natural products already available. Dr. Roper responded that another project is already studying natural products approved by the Food and Drug Administration; for her project, researchers want to focus on products associated with citrus. Responding to a question about the most optimistic regulatory pathway if the researchers discover a natural bactericide, Dr. Roper responded that advice from Bayer on a advisory panel was that a supernatant would be an easier pathway. Nano silver does not have wide acceptance in agriculture; an Environmental Protection Agency (EPA) advisory board member had to step off, but a former EPA advisor might be available. Following meetings with EPA, agency officials asked if a registrant for nano silver was available to advance the material's use as a product in agriculture. Little is know about silver in the phloem or xylem and various

studies are needed. A CDS member noted that the project has many moving parts and emphasized the critical importance of its phloem movement and nanoparticle elements. Dr. Roper noted that data on sick and survivor microbiomes were too preliminary. A CDS member asked about progress on culturing CLas and a member of the audience responded that some knowledge has been developed of genes that help the bacterium grow, but the culturing goal has not yet been achieved. It was noted that the CDS meeting was useful for members of different projects to meet and share ideas for advisory panels and other information. NIFA has considered a workshop for PIs and Interregional Research Project, or IR-4, researchers to discuss regulatory pathways. A CDS member suggested that it might be useful for NIFA to convene all project participants for two days to determine if synergy exists among project efforts.

- **Dr. YongPing Duan (USDA-ARS)**, *Assessment and Delivery of Antimicrobial Compounds for the Management of Citrus HLB*

Dr. Duan began by noting the difficulty of working on chemical-related research. He described the project's five objectives: 1) to perform a high-throughput screening of small molecules effective against HLB via a newly developed pipeline; 2) to determine the optimum application times and effective dosages of select antimicrobials through field trials; 3) to evaluate the fruit quality and quantity post-treatment and perform a chemical residue analysis; 4) to evaluate the economic viability and performance of proposed treatments; and 5) to inform stakeholders of the project's results and provide actionable recommendations for HLB therapy with cost-effective protocols. He said that the ideal phases of chemical research would lead from discovery, through validation, to field trials. Once chemicals are found, the issue becomes how chemicals can be delivered to growers, and in Florida, where many trees are dying, whether chemicals can revive the dying trees or protect survivors. Challenges facing the project are numerous. Research must find a chemical effective in eliminating CLas; it must be a small molecule, such as penicillin G 334.39 g/mol, and easily diffuse in a citrus plant or tissues. It must have no or very low phytotoxicity, be environment-friendly, and meet requirements for a non-medical use of antibiotics at a low cost. Lastly, it must receive regulatory approval.

In 2017, the project had a number of accomplishments. Researchers screened two small molecule libraries, one from the Torrey Pines Institute for Molecular Studies (TPIMS) and the other from Chembridge Research Laboratories (CRL), and identified a number of effective compounds that may be useful for controlling HLB. They evaluated 14 newly identified compounds in citrus and periwinkle plants using spraying, injection, and graft-based assays in a greenhouse setting. Three TPIMS and two CRL compounds showed greater efficacy than the others in eliminating or suppressing CLas. As planned, the researchers initiated field evaluations of Validoxyamine A, Aliette 80WG, and Carvacrol in three Florida and one Texas location. All the other locations except Immokalee yielded preliminarily positive results in the reduction of bacterial titers with different treatments. The project also initiated and conducted fruit quality testing, including for size, peel color, puncture resistance, fruit weight, juice weight, brix and acid. Preliminary data showed juice quality was maintained well.

Dr. Duan provided details of the chemical treatment processes used, including a graft-based assay for testing antimicrobial compounds that showed one compound to be more effective than a comparison chemical. But the treatment will not recover very sick trees. The question to be further explored is whether the treatment can be applied in the field to suppress infection early in the disease cycle. Going forward, researchers will combine tolerant citrus with anti-virulence

compounds for new plantings and eliminate other agents involved in the HLB complex because, even when CLas is eliminated, trees have slow growth. Researchers have identified other bacteria contributing to the HLB complex.

Q&A

During the question and answer period, when asked about culturing CLas, Dr. Duan explained that a unique, non-proprietary carbon source was used as a medium and he hopes to publish within 6-10 months. No single colony has been produced yet and researchers are trying to discover why. Research is also focused on the extent to which small-molecule chemicals are anti-bacterial in general or CLas-specific because the microbiome is important for plant health and if all microbes were killed it could harm the plant. While overly broad bactericides are a concern, it was noted that antibiotics to treat for pneumonia kill other microbes but the treatment is nevertheless beneficial to patients. CLas was kept in culture for almost 60 days, and some levels of dilution were acceptable, but not as dilution was raised higher. It was suggested that in culturing CLas, the environment must be considered and micro-capillaries should be used; Dr. Duan responded that the suggestion was a good one and a co-PI could work on that issue. A CDS member noted that culturing CLas was a major topic of research and asked if more culture-related projects were needed or current research was addressing the critical need. So far, culturing has not been accomplished.

- **Jude Grosser (University of Florida)**, *An Integrated Approach to the Accelerated Development of Rootstocks that Impart HLB Tolerance to Trees Grafted with Commercial Scions*

Dr. Grosser said that his project aims to find the underlying mechanisms of tolerance for future citrus trees. The project's primary goal is to develop and release rootstocks that impart adequate HLB tolerance/resistance to grafted commercial scions The second objective is to determine and better understand the mechanisms underlying any developed tolerance/resistance using molecular genetics, metabolomics, and physiology studies. The third objective is to collect and disseminate information to propagate and release rootstocks as soon as possible. Researchers want uniform plants for growers to use in the face of such issues as juvenility, which does not allow time for plants to grow and develop seeds. Various companies have propagation units working with the researchers. The ideal is HLB resistance, with partial resistance and tolerance as related goals, but it is unclear how to achieve the ideal. Tolerance has been demonstrated. A key question is whether it is possible that rootstock tolerance can impart partial resistance or tolerance in the scion of a grafted citrus tree. Significant evidence suggests it can. Sugar Bell is the most HLB-tolerant variety in Florida no matter what rootstock it is on. The researchers recognize the complexity of working with grafted trees; they want a streamlined breeding platform to deal with blight and other diseases.

Dr. Grosser presented photographs of field trials and data for Swingle and grapefruit rootstock trials. Valquarius on orange has shown significant genetic variety in the St. Helena Project, which has produced data on the optimum trees per acre to produce cumulative pounds solid per acre. Elite rootstock candidates come from several sources: formal rootstock trials; other field trials; ongoing 2X and 4X breeding; robust "Gauntlet" screening; and super-root mutants. The loss of roots is a major issue with HLB infection. The project is identifying winners for all field trials, with US942 being the most popular rootstock for growers. Data are collected on elite and

poor performers. Dr. Grosser presented data on elite rootstocks derived from various sources. Data on younger Gauntlet trees are showing tolerance. Data on salt-tolerant seedlings suggest that abiotic stress tolerance might do well for HLB stress tolerance. Half a dozen trees appear to show a transition from infected to uninfected condition, which looks like a recovery effect but the findings must be validated. One tree sourced through Gauntlet screening was so robust that researchers took additional cuttings and grafted seven scion hybrids. Researchers are improving their ability to screen hybrids. Initial testing with infected Murcott hybrids, which react quickly, have shown bacterial titer declining. When taken into the field, the Murcott hybrids produced data suggesting that it might be a good indicator scion. It is challenging to understand the mechanisms of tolerance, although research is providing some clues. In Valencia on Swingle graftings researchers found both symptomatic and unsymptomatic trees. There are complex responses in the trees. An IPM approach will be needed to tackle HLB.

Q&A

During the question and answer period Dr. Grosser noted that the interaction between nutrition and genetics in trees is a huge issue that requires immediate research. Citrus Research and Development Foundation greenhouse experiments have studied nutrition deficiencies. Growers are trying different approaches to restore nutrient balance. In Dr. Grosser's view, HLB is a root disease. Studies are ongoing to assess manganese effects.

In addition to the Project Directors' presentations, CDS members were invited to a Poster Session that was set up in the meeting room to learn more about the projects.

PART III: Citrus Disease Research Efforts and Activities

OVERVIEW OF THE CDRE PROGRAM AND PRESENTATION OF FY2017 CDRE GRANT AWARD TOPICS

Dr. Tom Bewick (National Program Leader, NIFA) gave an overview of CDRE program activities and the current status of awards. He began by noting that the new Program Specialist is Megan O'Reilly; the Relevance Review Panel Manager is Harold Browning; and the Scientific Merit Review Panel Manager is Neil Gudmestad, who will be replaced next year by Jeff Chang of Oregon State University.

Dr. Bewick then reviewed the submissions data. For the first submission date, NIFA received 38 pre-applications. The pre-applications were assigned to four panels based on CDS priorities, with each panel having nine industry reviewers. The panels invited 26 full applications, and five awards were announced, a 20 percent award rate. For the second submission date, which has a deadline of February 15, CDRE received 10 pre-applications, including several from non-citrus teams. However, none of the submissions were in the final stages. CDRE wants projects that would be complete in 18-24 months. Three proposals were invited to submit full applications. Approximately $2.4 million is available. In explaining the selection process, Dr. Bewick noted that the Relevance Review Panels decided which pre-applications to invite, ranking them based on the importance of the research to industry. The Scientific Merit Review Panel rated projects by merit, and then developed its funding recommendations by combining the relevance and merit rankings. Dr. Browning was present at the meeting when the Scientific Merit Panel developed

funding recommendations, which were made giving significant weight to a project's relevance. Dr. Bewick noted that a press release had been published on the five 2017 awards, and the awardees will attend the 2019 CDS meeting. The NIFA Current Research Information System website, or CRIS, provides both a 250-word layman-level summary of projects as well as a full record describing objectives, methods, and other information.

CDS members received 250-word summaries of the 2017 awards and Dr. Bewick listed the titles on a slide:

- *Biopesticidal Dsrna Therapy for Psyllid Mortality and Abatement of Vector-Mediated CLas Transmission*
- *Citrus Under Protective Screen (CUPS) For HLB Management*
- *Transgenic Success-Guided Reproduction of Huanglongbing Disease Resistance/Tolerance in Citrus by Gene Editing*
- *Development of Non-Transgenic HLB Resistant Citrus Varieties Using CRISPR-Cas9*
- *Accelerating Implementation of HLB Tolerant Hybrids as New Commercial Cultivars for Fresh and Processed Citrus*

DISCUSSION OF CDRE ACTIVITIES AND GRANTS AWARDED IN FY2017

During the discussion session, Dr. Bewick affirmed that the number of grant applicants was declining, from 69 in the first year to 38 in the current year. But projects are in the pipeline. It was clarified that if Congress does not pass a new Farm Bill, the CDS would continue to meet and consult with NIFA, even if no new funding is available for the Subcommittee's consideration. But citrus is a specialty crop, a research area that has funding every year, so even if the CDRE expires the CDS could recommend specialty crop priorities and NIFA would take the recommendations seriously.

Responding to a CDS member's comment that it would be helpful to have information as far back as the first year of CDRE funding, Dr. Bewick stated that all projects are available on the Request for Applications webpage and other information portals. A CDS member noted that researchers would benefit from knowing what was previously funded. It was agreed that Megan O'Reilly will work with the NIFA information technology staff to update the webpage housing all NIFA projects and reports, and Michele Esch will develop a link that CDS members and researchers can go to directly. NIFA also has a Data Gateway webpage that contains detailed information and enables targeted searching—such as, for example, all citrus disease research, including recently funded projects. Dr. Bewick demonstrated how users could locate information through relevant portals.

A CDS member asked how the Subcommittee's priority recommendations fit into the CDRE award determination. Dr. Bewick explained that the 2017 ranking was used to give greater weight to projects with high relevance and scientific merit scores; if those scores were equal, a project that matched the CDS's top-ranked priority received greater weight than a project matching the CDS's fourth-ranked priority.

Members discussed the issue of supplemental funding for existing projects. Dr. Bewick explained that NIFA cannot lengthen a project beyond five years but can make supplemental awards, although he would need to research the process. A CDS member requested that NIFA inform them about the process once it is clarified. Dr. Harold Browning stated that a project could apply in the following year for a complement to its current project. A member asked if the CDS could recommend that no more new projects receive funding and that all remaining funds be set aside for supplemental awards. Dr. Bewick responded that NIFA has the authority and if CDS made such a recommendation the leadership would have to consider it.

CITRUS RESEARCH ACTIVITIES AT ARS

Dr. Gail Wisler (Retired, National Program Leader for HLB/ACP Research, USDA- Agricultural Research Service [ARS]) gave an update on ARS citrus diseases research. She began by describing differences among the USDA partners working on HLB solutions: ARS, NIFA, and the Animal and Plant Health Inspection Service (APHIS). ARS is a "problem solving agency" employing 6,000 people in 90 research stations. NIFA, an extension agency, employs only 350 people, but provides essential support for universities and funds extensive research. APHIS employs 7,000 people to fulfill its regulatory responsibilities, including 5,000 inspectors at ports, farms, and other locations. Industry partners are essential to the HLB effort and are the group all three agencies serve.

USDA's HLB National Plan targets all three components of the problem. The ACP vector, with its exploding populations and spreading range, is targeted for eradication and to block its transmission of the disease. The associated pathogens (CLas, CLam, CLaf) are targeted to locate their sites in plants through sampling and diagnosis. The citrus hosts are targeted as a permanent reservoir and to develop resistance, the bottom-line need to save citrus. When HLB hit Florida in 2005-2006, ARS responded with an "all hands on deck" that refocused research at ARS locations around the country on various aspects of the disease and solutions. ARS conducted basic and applied research, which complemented each other. The template for ARS research included detection technologies; disease resistance; ACP management; blocking/inhibiting transmission by ACP; and therapeutic approaches for trees. Dr. Wisler urged groups to get together and compare notes.

She presented a map showing the increase of ACP over time, with repeated findings in central California amplifying the risk that ACP will become established in the state and CLas will be introduced into commercial citrus. HLB quarantine areas have been established in California, with materials in Riverside restricted to the repository. In the event of a national disaster affecting the industry, the Fort Collins, Colorado, National Laboratory for Genetic Resource Preservation (NLGRP) decided to cryo-preserve all accessions in a vault. Riverside Citrus had 540 pathogen-free accessions, with 451 cryo-processed as of March 2017, but as of 2018 the Riverside quarantine prohibits shipping budwood to NLGRP. Riverside is cryo-processing accessions in-house.

Dr. Wisler presented information about research conducted at the ARS Parlier, California, station, that has identified and targeted CLas virulence genes, with preliminary tests showing enhanced growth of citrus trees treated with selected compounds. Another study has resulted in

improved CLas detection. In research on therapeutic antimicrobials, three independent trials demonstrated 10-15 percent yield improvement after a one-year application, and research is ongoing to optimize uptake of the treatments. Trials to test bactericides' ability to improve citrus production in the presence of HLB have shown that adjuvants matter. Dr. Wisler presented information about other studies pertaining to peptides that block transmission; ACP attract-and-kill strategies; biological control of ACP; a first-ever successful transformation of psyllids using CRISPR-Cas9; tolerance breeding; HLB resistance; and genome-targeting technology to precisely modify citrus DNA. She showed that six hybrid rootstocks released by USDA have good tolerance to HLB with commercial fruit cultivars, and materials are being transferred to California for field trials. In Florida, over the past two years, new citrus plantings have used more than two million trees on the USDA rootstocks with good tolerance. ARS is also researching HLB-tolerant hybrids with high-quality flavor.

Dr. Wisler described the ARS-wide 2017 Grand Challenge that set the goal: "Transform agriculture to deliver a 20 percent increase in quality production at 20 percent lower environmental impact by 2025." The ARS administration recognized HLB as one of agriculture's greatest challenges. While more tools are needed to fight the disease, for now tools can be combined in the three areas of: new rootstocks and scions; antimicrobials and adjuvants; and improved application technologies to reduce costs and materials used. In 2017, $18.7 million went to projects coded for citrus, and $2.3 million for citrus greening.

DISCUSSION OF ARS RESEARCH ACTIVITIES

During the question and answer session, Dr. Wisler was asked about the quarantine zone she depicted, and she replied that Georgia should be able to move material within weeks. Samples have been drawn and analyzed.

USDA HLB MULTI-AGENCY COORDINATING COMMITTEE UPDATES AND ACTVIVITIES

Dr. Angela McMellen-Brannigan (USDA, Animal and Plant Health Inspection Service), speaking via teleconference, stated that several vector control projects were being funded using $2 million of $11 million available: 1) an attract-and-kill device for ACP; 2) the development of a mass-rearing method for the parasitoid, Tamarixia radiata; 3) the augmentation of the production of ACP at existing California facilities; 4) strengthening the ACP biocontrol program in Texas; and 5) addressing whether continued vector management under HLB stress is needed in response to industry questions about spending more money to control ACP if it is not making a difference.

Two projects are directed at the field management of HLB using approximately $500,000 out of $8 million: 1) the control of citrus HLB for new plantings in Florida with integrated management and 2) the mitigation of citrus HLB by thermotherapy treatments in Texas. Projects funded at approximately $2 million directed at early detection technologies are: 1) establishing a baseline reference for early detection technologies for citrus trees in California for non-regulatory sampling, using trapping and testing; 2) determining optimum ACP sampling protocols in California to assess vector management treatments and to improve the prediction of HLB risk

through ACP Ct value analysis; and 3) and expansion of the first project, focused on establishing a baseline for healthy citrus for HLB early detection technologies in California: CA-1 phase 2. An additional $1.5 million is being spent on other projects: 1) retrofitting two screenhouse sections to receive citrus varieties; 2) purchasing equipment for a Southern California Citrus Containment Lab for HLB research; 3) canine detection of citrus HLB; and 4) the coordination of citrus breeding programs for HLB mitigation, with a two-day workshop at the end of February to identify and overcome roadblocks.

Not all of the $11 million has been spent, so money will be left at the end of the fiscal year, and the HLB-MAC wants to evaluate if biocontrol and early detection are worthwhile priorities. Coordination is important to avoid duplication and to spend the funds wisely.

DISCUSSION OF APHIS ACTIVITIES

Dr. McMellen-Brannigan noted that at the request of the CRDF, the National Academy of Sciences (NAS) is conducting a comprehensive review of HLB efforts since 2005, following up on a 2009-2010 review that NAS published. Forums and webinars were held and the report drafting is now underway, with a final due in March and publicity to follow 60 days later, although CRDF will use it in April.

PART IV: Establishment of FY2018 Agenda and Priorities for the Citrus Disease Research and Extension

OVERVIEW OF CHARGE TO THE SUBCOMMITTEE FOR RECOMMENDATIONS TO NIFA

DFO Michele Esch opened the discussion by presenting an overview of the CDS charge as an advisory group to the USDA Secretary.

WORKING SESSION: FORMALIZING RECOMMENDATIONS AND PRIORITIES FOR THE FY2018 CDRE PROGRAM

DFO Michele Esch explained that the goals for the session were to evaluate and review the ongoing research, to comment on the grants, and to discuss other related business.

She presented a list of the 2014 priorities, which were in the five areas of 1) bacterium; 2) consumers; 3) productions systems; 4) regulation; and 5) vectors. She noted that in 2014 there were many priorities within the five categories. In 2015, the priorities were narrowed to five that were rank-ordered: 1) chemical and heat therapy systems; 2) culturing; 3) early detection; 4) resistant germplasm; and 5) attract-and-kill, suppression, and other lower priorities. In 2016, four priorities were identified but not rank-ordered: culturing, developing tolerance or resistance, early detection, and prevention or suppression therapies.

Ms. Esch posted the 2017 rank-ordered priorities for discussion by the CDS. They were:

1. Therapies to prevent or suppress *Candidatus Liberibacter asiaticus* (CLas) bacteria within trees.

2. Development of tolerance or resistance in commercial citrus in all production areas with a focus on delivery of new cultivars (or rootstocks and scions) using all available strategies.
3. Systems for delivery of therapies into the phloem of citrus trees.
4. Culturing or cultivating the CLas bacterium.
5. Early detection of the bacterium in host and vector.
6. Development of pre- and post-harvest tools to maximize citrus fruit quality for use in fresh fruit or processed products.

A CDS member asked if there was enthusiasm among researchers for priority 3, delivery systems. Dr. Tom Bewick responded that because this was a new priority, like priority 6 for fruit quality, fewer proposals were submitted on that topic. A member suggested that it would be helpful to see which categories the 38 proposals fell into, and Dr. Bewick responded that he would bucket the proposals to give the CDS a view of the areas drawing responses.

- **New Priorities: Are there other areas for focus?**

CDS Chair Tom Jerkins asked members if any priorities should be removed. A member commented that the bacteria must be cultured, so perhaps funds should be set aside to supplement current research or to support a new idea. It was noted that two culturing projects are ongoing; a third was discussed but not funded. A member asked if it would be helpful to have other types of experts involved in culturing research. Dr. Harold Browning noted that in 2008 experts interested in culturing were convened. Significant work is being done on screening, metabolomics, and related areas, and strides are being made in culturing. The two projects are not the only research being done on culturing. Dr. Browning favored keeping culturing on the priority list. Members discussed the cut-off for successful culturing, such as 60-80 days, and it was noted that the duration and population levels have not been stabilized yet. Culturing is usually a 4-5 year process, so the pace of progress over one year for CLas culturing is ahead of the usual schedule. A participant observed that additional funding to hire more researchers would accelerate progress. Cultures can be done in a liquid medium, but details must be figured out that would help the culture grow; the process can be accelerated, even without a pure culture, and success is fairly close. A member asked if the two culturing projects communicate with each other, noting that with the human genome project stronger interaction is needed and would help. But it was noted that many candidate bacteria are never cultured despite years of effort that keeps the bacteria alive but not growing. Researchers have attended workshops and learned nothing because there is no overlap between the approaches the two culturing projects are pursuing, so it will not help. Chair Jerkins concluded that culturing remains elusive and should remain on the priority list.

A member added that a process is needed to be sure supplemental funding for culturing can be obtained if necessary without having to resubmit a completely redone project proposal. Dr. Bewick responded that in all cases, peer review would be required. Members discussed the possibility of setting aside a portion of the remaining funding, such as one-third or half, for any supplemental research needed, including dollars reserved for culturing. Dr. Bewick and the members reviewed funding amounts, leading to the conclusion that $24.4 million remains, including $2.4 million from 2014. Chair Jerkins requested that for clarity an Excel spreadsheet be created so the CDS can see the numbers, and it was agreed NIFA can create such a spreadsheet for the members. Dr. Tom Bewick informed the CDS that the members could

recommend applying unspent funds for later use as supplemental dollars, but he could not say with certainty that NIFA could implement such a recommendation. The Farm Bill stipulates that funds are to be "available until expended." Awards are restricted to five years, so a project begun in 2015 would have to end by 2020. In the Specialty Crop Research Initiative program, approximately $10 million has been returned to the U.S. Treasury.

After obtaining agreement that none of the six 2017 priorities should be removed, CDS Chair Jerkins asked if any should be added. CDS member Joe Davis, Jr., raised the issue of root health. He noted that in Florida most trees have been infected for some time, but as a grower he has continued to make a profit each year, root health is the most important factor. Bactericides for leaves are available, but bacterium in the roots is the most critical issue. A key question is how to improve the root health of HLB-infected trees. HLB has wiped out hundreds of growers, but with prices up from $1 to $3 per pound solid, healthier roots would help sustain growers' profitability. Many studies exist on soil health and other useful areas, but research has not focused on what causes roots to be unhealthy. Members tried out various additional wording for the 2017 priority number 3, agreeing to modify the statement to read: Systems for delivery of therapies into the phloem of citrus trees, *including the root system* (addition italicized). A member commented that the goal is not to just deliver therapy to the roots but to have scientists explain the dynamics of the disease and the root system. After a brief discussion about whether the issue was root health or the whole tree, the CDS also approved a new priority that read: *Improve productivity of infected trees, including root health*.

Project Director Dr. YongPing Duan offered his view that 2017 priority number 2 required a reference to the variety of pathogenic strains because there are clear differences in strains from Florida and California, so strains from all major areas should be used. A CDS member asked if that would require a new $4 million study or if it could be justified under the current program. Relevant strains could be predicted, but it would take significant funding to propagate and grow them. With the *Liberibacter* evolving and changing, strains must be biologically characterized and the effects of bacterial evolution on existing strains must be understood. Members agreed to modify priority 2 to read: Development of tolerance or resistance in commercial citrus in all production areas with a focus on delivery of new cultivars (or rootstocks and scions) using all available strategies, *with consideration of pathogen genetic diversity* (addition italicized).

A project researcher asked about possibly modifying 2017 priority number 6, on fruit quality, to reflect the concept of "consumer-driven" quality. But it was noted that NIFA does not fund marketing campaigns and the proposed emphasis was outside the CDS charge. Members agreed number 6 was good as-is.

CDS Chair Jerkins called for a motion to accept all seven of the priorities listed for 2018. A motion was made, seconded, and the list was unanimously adopted. He then opened the floor to discussion of how the priorities should be ranked in importance. Members made the case for different items to receive higher ranking; for example, one member suggested that the new priority of improving infected trees' productivity should be the top priority because keeping the trees alive is critical for the citrus industry's survival. Following discussion, the CDS adopted a procedure whereby members could provide their suggested rank ordering, and the results were tallied to produce the following consensus on the 2018 priorities list:

1. Therapies to prevent or suppress *Candidatus Liberibacter asiaticus* (CLas) bacteria within trees.
2. Development of tolerance or resistance in commercial citrus in all production areas with a focus on delivery of new cultivars (or rootstocks and scions) using all available strategies, with consideration of pathogen genetic diversity.
3. Improve productivity of infected trees, including root health.
4. Systems for delivery of therapies into the phloem of citrus trees, including the root system.
5. Culturing or cultivating the CLas bacterium.
6. Early detection of the bacterium in host and vector.
7. Development of pre- and post-harvest tools to maximize citrus fruit quality for use in fresh fruit or processed products.

- **Identify Agenda and Budget for FY2018 CDRE Program**

A CDS member made a motion to add language to the FY2018 letter to the Secretary that would convey the idea of reserving a portion of any remaining funding to supplement existing projects. Members discussed what percentage would be appropriate to set aside. Dr. Bewick stated that the proposal for one-third of $24 million, or $8 million, was too much to reserve, given that the amount needed for new proposals is unknown. Language was suggested calling for "up to" 20 or 25 percent if funds remain after new proposals. The final language that members approved called for the CDS to convey to the NIFA director that "*the intent is for an amount of funding, not to exceed 25 percent, to be awarded to advance existing projects if justified by merit in light of these seven priorities*."

Members further discussed the supplemental funding, noting that 75 percent of funds would go to projects fitting the 2018 priorities and up to 25 percent would go to the objectives of funded priorities as a supplement to accelerate delivery of promising HLB solutions. Responding to a question about whether a "full-blown pre-proposal" would be needed to apply for a supplement, Dr. Bewick responded affirmatively. He added that a format would be stipulated for either supplemental or renewal funding. A member commented that the idea is to encourage requests for supplemental funding early if possible.

DISCUSSION ON RELEVANCY REVIEW PROCESS FOR SCRI/CDRE PROGRAM

DFO Michele Esch sought CDS comments on grants awarded as a way to test how the awards process is working.

Members raised concerns about the fact that the five awards made in 2017 included a project on *Citrus Under Protective Screen (CUPS) for HLB Management*. A member suggested that the Relevance Review process might be flawed if a CUPS project was approved because it does not fall within the CDS 2017 priorities list. Another commented that less than 1 percent of Florida growers would have thought a CUPS project was important enough to spend $3 million on. Dr. Tom Bewick noted that seven of the 38 proposals were not within the scope of the 2017 priorities, but the Relevance Review Panel raised the CUPS proposal and it received a high Scientific Merit ranking. Members said the result reveals that although the CDS said it was not a priority, the Relevance Review made it a priority, raising the issue of whether the CDS wanted to

comment on the matter. Dr. Bewick said that if the CDS comments, NIFA would have to take action; if the CDS does not want projects outside the priorities list to be funded, language would have to be added directing that such projects be excluded. A CDS comment would have to be raised to the Secretary's level for a response to be developed and approved. Members expressed interest in seeing the project proposals that fell outside the priorities and Dr. Bewick said that information would be provided. Chair Tom Jerkins noted that the CDS is not necessarily calling for any action, and pointed out that the CUPS result was the first time for such an occurrence in four years, or one in 24 projects. A member said that it was unfair to cast doubt on the scientists' judgment.

Chair Jerkins suggested that, since members were not asking for any action to be taken on the CUPS project, there should be no comment. No members disagreed, but one emphasized that the CUPS project should not be duplicated. The question was raised as to whether the Citrus Research Board received a proposal for a similar project, the board would be aware of NIFA-funded projects. But it is hard to know if Relevance Review panelists would have access to all ongoing research; in some cases they would, but in others not. NIFA asks applicants if another agency has funded their project or a similar one, and if another agency has, NIFA would withdraw funding. Chair Jerkins also asked why only one of 14 projects was funded that fell within the scope of the top priority for 2017. Dr. Bewick responded that only five of the 14 were invited to submit full applications.

Part V: Other Recommendations/Future Programming

CDS Chair Tom Jerkins turned to the topic of changing the CDS membership. DFO Michele Esch pointed out that all but three members had reached their maximum six-year terms and would rotate off, although a request can be made to extend the terms of three members for an additional year. Members agreed that extensions should be requested because it would be too disruptive for CDS to lose all except three members at once. Ms. Esch said NAREEE would issue a call to replace three members for appointments starting October 1, 2018. Citrus producers are required, with these numbers from each state: Florida (5), California (3), and Texas (1). Chair Jerkins requested that members who have reached their six-year limit send Ms. Esch an email indicating their willingness to serve an additional year. She requested that CDS members suggest candidates to serve as new members.

A member asked what the charge would be for CDS in the absence of a Farm Bill that renews its full charge. Ms. Esch responded that the basic charge would remain: "Advise the Secretary on citrus research, extension, and development needs through the Advisory Board." The National Genetic Resources Advisory Council could solicit CDS input on major issues the Council is addressing, or the CDS could raise other issues. Only the CDRE-related charge would end.

Dr. Harold Browning commented that for project PIs who travel to meetings it would be beneficial to schedule time for informal interactions, an activity that they currently lack time to engage in. Dr. Tom Bewick responded that he and Megan O'Reilly had discussed holding a one-day session, apart from the CDS meeting, during which Project Directors could meet with CDS members, hold poster sessions, and give oral presentations.

Members discussed possible locations for the 2019 CDS meeting. Arizona and Fresno, California, were named as potential locations.

PUBLIC COMMENT

There were no public comments and the meeting adjourned at 5:45 p.m.

FRIDAY, JANUARY 26, 2018

The CDS members and other meeting participants met at the ARS Horticultural Research Laboratory (HRL) at 8:30 for a tour of the facility and fields where citrus HLB-related research is being conducted. Laboratory Director Brian Scully met the group and led the tour. Supervisory Research Horticulturist Liz Baldwin described the work of the sensory laboratory where citrus taste testing is conducted. Research Geneticist Kim Bowman described her greenhouse work breeding citrus rootstocks that are tested in the fields. Plant Physiologist Greg McCollum described his greenhouse work studying HLB detection in plants. Research Horticulturist Ed Stover described his greenhouse work breeding hybrids. Research Plant Pathologist YongPing Duan described his greenhouse studies of HLB experimental model systems. Following the facility tour, the CDS visitors and HRL researchers drove to the field sites. They first met with Research Entomologist Joe Patt who explained his project testing a Photonic Fence that uses laser guns to identify and kill psyllids. The group then toured sections of Blocks 1 and 2 of the groves where they observed results of various hybrid combinations that have shown various degrees of success in achieving HLB tolerance. Plant Pathologist Randy Driggers showed the CDS visitors fruit trees providing evidence that HLB resistance or tolerance is occurring in cultivated citrus.

MEETING ADJOURN

The tour ended at 11:30 a.m.

RESOLUTIONS AND RECOMMENDATIONS

- A CDS member suggested that it would be helpful to see the 38 project proposals for last year categorized according to which of the 2017 priorities they matched.
- CDS members expressed interest in the possibility of setting aside a portion of remaining CDRE funds for use as supplemental dollars for existing research projects, such as culturing research; for clarity on the funding issue, they requested that NIFA create an Excel spreadsheet so the CDS can see the amount of CDRE funds that have been spent and the amount remaining.
- The CDS, after reviewing the 2017 priorities, modifying two, and adding a new one, unanimously adopted the new list of priorities.
- After discussion, the CDS conducted a voting procedure to rank order the 2018 priorities and adopted a final rank order that will be influential in funding recommendations, with higher priority goals receiving greater weight.
- The CDS supported NAREEE requesting an additional one-year extension for members whose term has reached the maximum six years.

ACTION ITEMS

- Megan O'Reilly will work with the NIFA information technology staff to update the webpage housing all NIFA projects and reports, and Michele Esch will develop a link that CDS members and researchers can go to directly.
- NIFA will inform the CDS members about the process for making supplemental funding awards to existing projects.
- Tom Bewick will classify the 38 research project proposals received last year according to which of the six 2017 CDS priorities the proposals matched and make the information available to CDS members.
- NIFA will create an Excel spreadsheet so the CDS can see the amount of CDRE funds that have been spent and the amount remaining.
- CDS members who have reached the maximum of their six-year terms will send Michele Esch an email indicating whether they would be available to extend another year.
- Michele Esch will request a one-year extension for three CDS members who have reached their six-year term maximum but are willing to extend their service another year.
- NAREEE will issue a call for three new CDS members for appointments starting October 1, 2018.
- CDS members will suggest candidates to serve as new CDS members.

APPENDIX A: LIST OF MEETING ATTENDEES

Note: A list of public attendees is available from the NAREEE Advisory Board Office.

Thursday, January 25, 2018

PART I: WELCOME AND INTRODUCTIONS

CDS Members Present: Justin D. Brown, Joe Davis, Jr., David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr. Etienne Rabe, Donald Roark
CDS Members Absent: Paul Heller
NAREEE Advisory Board Staff: Michele Esch, Shirley Morgan-Jordan
Other USDA Staff: Dr. Tom Bewick, Megan O'Reilly
Invited Guests: Dr. Harold Browning, Dr. Gail Wisler,
Project Directors: Bryony Bonning, Feng Luo, Caroline Roper, YongPing Duan, Jude Grosser
Other Guests: Ute Albrecht, Yiannis Ampatzidis, Liz Baldwin, Kim Bowman, Judith Brown, Harold Browning, Maria Campos, Gitta Cocker, Bill Dawson, Zhanao Deng, Dean Gabriel, David Gang, Christopher Gardner, Fred Gmitter, Goutam Gupta, Catherine Hatcher, Melinda Klein, Graciela Lorca, Wenbo Ma, Zhonglin Mou, Greg Nelson, Fernando Pagliai, Chandrika Ramadugut, Swadeshmukul Santra, Arnold Schuman, James Snyder, Kirsten Stelinksi, Ed Stover, Nian Wang, You Wang, Lisa Weaver, Shujian Zhang

PART II: SCRI/CDRE PROJECT DIRECTOR PRESENTATIONS

CDS Members Present: Justin D. Brown, Joe Davis, Jr., David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr. Etienne Rabe, Donald Roark
CDS Members Absent: Paul Heller
NAREEE Advisory Board Staff: Michele Esch, Shirley Morgan-Jordan
Other USDA Staff: Dr. Tom Bewick, Megan O'Reilly
Invited Guests: Dr. Harold Browning, Dr. Gail Wisler
Project Directors: Bryony Bonning, Feng Luo, Caroline Roper, YongPing Duan, Jude Grosser
Other Guests: Ute Albrecht, Yiannis Ampatzidis, Liz Baldwin, Kim Bowman, Judith Brown, Harold Browning, Maria Campos, Gitta Cocker, Bill Dawson, Zhanao Deng, Dean Gabriel, David Gang, Christopher Gardner, Fred Gmitter, Goutam Gupta, Catherine Hatcher, Melinda Klein, Graciela Lorca, Wenbo Ma, Zhonglin Mou, Greg Nelson, Fernando Pagliai, Chandrika Ramadugut, Swadeshmukul Santra, Arnold Schuman, James Snyder, Kirsten Stelinksi, Ed Stover, Nian Wang, You Wang, Lisa Weaver, Shujian Zhang

PART III: CITRUS DISEASE RESEARCH EFFORTS AND ACTIVITIES

CDS Members Present: Justin D. Brown, Joe Davis, Jr., David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr. Etienne Rabe, Donald Roark
CDS Members Absent: Paul Heller
NAREEE Advisory Board Staff: Michele Esch, Shirley Morgan-Jordan

Other USDA Staff: Dr. Tom Bewick, Megan O'Reilly
Invited Guests: Dr. Harold Browning, Dr. Gail Wisler, Dr. McMellen-Brannigan (via phone)
Project Directors: Bryony Bonning, Feng Luo, Caroline Roper, YongPing Duan, Jude Grosser
Other Guests: Ute Albrecht, Yiannis Ampatzidis, Liz Baldwin, Kim Bowman, Judith Brown, Harold Browning, Maria Campos, Gitta Cocker, Bill Dawson, Zhanao Deng, Dean Gabriel, David Gang, Christopher Gardner, Fred Gmitter, Goutam Gupta, Catherine Hatcher, Melinda Klein, Graciela Lorca, Wenbo Ma, Zhonglin Mou, Greg Nelson, Fernando Pagliai, Chandrika Ramadugut, Swadeshmukul Santra, Arnold Schuman, James Snyder, Kirsten Stelinksi, Ed Stover, Nian Wang, You Wang, Lisa Weaver, Shujian Zhang

PART IV: ESTABLISHMENT OF FY2018 AGENDA AND PRIORITIES FOR THE CITRUS DISEASE RESEARCH AND EXTENSION

CDS Members Present: Justin D. Brown, Joe Davis, Jr., David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr. Etienne Rabe, Donald Roark
CDS Members Absent: Paul Heller
NAREEE Advisory Board Staff: Michele Esch, Shirley Morgan-Jordan
Other USDA Staff: Dr. Tom Bewick, Megan O'Reilly
Invited Guests: Dr. Harold Browning, Gail Wisler, Angela McMellen-Brannigan (via phone)
Project Directors: Bryony Bonning, Feng Luo, Caroline Roper, YongPing Duan, Jude Grosser
Other Guests: Ute Albrecht, Yiannis Ampatzidis, Liz Baldwin, Kim Bowman, Judith Brown, Harold Browning, Maria Campos, Gitta Cocker, Bill Dawson, Zhanao Deng, Dean Gabriel, David Gang, Christopher Gardner, Fred Gmitter, Goutam Gupta, Catherine Hatcher, Melinda Klein, Graciela Lorca, Wenbo Ma, Zhonglin Mou, Greg Nelson, Fernando Pagliai, Chandrika Ramadugut, Swadeshmukul Santra, Arnold Schuman, James Snyder, Kirsten Stelinksi, Ed Stover, Nian Wang, You Wang, Lisa Weaver, Shujian Zhang

PART V: OTHER RECOMMENDATIONS/FUTURE PROGRAMMING

CDS Members Present: Justin D. Brown, Joe Davis, Jr., David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr. Etienne Rabe, Donald Roark
CDS Members Absent: Paul Heller
NAREEE Advisory Board Staff: Michele Esch, Shirley Morgan-Jordan
Other USDA Staff: Dr. Tom Bewick, Megan O'Reilly
Invited Guests: Dr. Harold Browning, Gail Wisler
Project Directors: Bryony Bonning, Feng Luo, Caroline Roper, YongPing Duan, Jude Grosser
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Friday, January 26, 2018

U.S. HORTICULTURAL RESEARCH LABORATORY (HRL) TOUR

Tour participants were Brian Scully, Liz Baldwin, Kim Bowman, Greg McCollum, Ed Stover, YongPing Duan, Joe Patt, Randy Driggers from HRL, together with the majority of CDS members, Shirley Morgan-Jordan, and several meeting guests.

APPENDIX B: PRESENTATIONS

Note: Presentations made to CDS members are available upon request to the NAREEE Advisory Board Office:

- Bryony Bonning, University of Florida, presented on *Bt Toxin-based Strategies for Management of* Diaphorina citri *and Citrus Greening*

- Feng Luo, Clemson University, presented on *Selection, Molecular and Genetic Analysis of HLB Tolerant/Resistant Variant Citrus Plants*

- Caroline Roper, the Regents of the University of California, presented on *Deployment Of A Spectrum Of Bactericides To Cure And Prophylactically Treat Citrus Huanglongbing*

- YongPing Duan, USDA-ARS, presented on Identification, *Assessment and Delivery of Antimicrobial Compounds for the Management of Citrus HLB*

- Jude Grosser, University of Florida, presented on *An Integrated Approach to the Accelerated Development of Rootstocks that Impart HLB Tolerance to Trees Grafted with Commercial Scions*